REMARKS

I. **Status of the Claims**

Claims 1, 10, and 11 have been amended. Claims 15-19 have been added. Claims 7 and 8 have been cancelled. After amending the claims as set forth above, claims 1-3, 5, and 10-19 are now pending in this application.

II. **Claim Rejection – 35 U.S.C. § 103 – Sakamoto**

The Examiner has rejected claims 1-3, 5, 7, 8, and 12-14 under 35 U.S.C. 103(a) as being unpatentable over Sakamoto (Pub No. US 2002/0024114 A1) (Sakamoto).

The Examiner has rejected claims 10 and 11 under 35 U.S.C. 103(a) as being unpatentable over Sakamoto and Gardes et al. (Pub No. US 2003/0066184 A1) (Gardes).

The rejections of the claims is respectfully traversed in view of the claims as amended herein.

A. Sakamoto does not disclose or suggest a bipolar transistor having a metal layer (i) providing metal track contacts that directly contact the base and emitter regions and (ii) having a substantially uniform thickness.

Independent claim 1 recites a bipolar transistor comprising:

> a first semiconductor region of a first conductivity type defining a collector region;
>
> a second semiconductor region of a second conductivity type defining a base region;
>
> a third semiconductor region of said first conductivity type defining a emitter region; and
>
> a metal layer providing metal track contacts that directly contact the base region and the emitter region;
>
> wherein the emitter region defines a first surface, the base region extending to the first surface in locations defined by apertures through the emitter region, the metal layer overlying the first surface;

> wherein the bipolar transistor has a specific area resistance less than 500mOhms.mm^2;
>
> wherein the metal layer has a thickness that is substantially uniformly greater than $3\mu m$; and
>
> wherein voltage drops in the metal track contacts, which contact the base region and the emitter region, are reduced when the bipolar transistor is in an on state to distribute a voltage bias to a junction of the base region and the emitter region such that saturation resistance is reduced by an amount greater than 0% and up to 30% compared to the same bipolar transistor having a metal layer of thickness less than 3 μm.

Thus, (i) a metal layer provides metal track contacts that **directly contact** the base **and** emitter regions; and (ii) a thickness of the metal layer is **substantially uniform** (and greater than $3\mu m$). With such a configuration, a voltage bias is distributed to the emitter-base junction to provide a reduction in saturation resistance of up to 30% compared to the saturation resistance of the same bipolar transistor having a metal layer thickness less than 3um. Sakamoto, alone or modified in the manner suggested by the Examiner, does not teach, suggest, or render predictable a bipolar transistor, as recited in claim 1, including these features.

According to the Examiner, Sakamoto discloses

> a first semiconductor region of a first conductivity type defining a collector region (see Fig. 1a, n collector region 21);
>
> a second semiconductor region of a second conductivity type defining a base region (see Fig. 1a, p base region 22);
>
> a third semiconductor region of said first conductivity type defining a emitter region (see Fig. 1a, n emitter region 24); and
>
> a metal layer providing contacts to said base and emitter regions (see Fig. 1a, metal layer 26+27 provided);
>
> wherein the emitter region defines a first surface, the base region extending to said surface in locations defined by apertures through emitter region, said metal layer overlying said first surface (see Fig. 1a, emitter region 24 with first surface, base region extended through apertures through emitter region, metal layer from 26+27),
>
> wherein the bipolar transistor has a specific area resistance less than 500mOhms.mm2 (see Remarks dated 10/19/2009, page 7,

> second paragraph, with the matrix design, possible to attain specific area resistance less than 500 mOhms.mm2).

See Office Action at section 4.

However, in contrast to claim 1, Sakamoto does not disclose that the metal layer provides metal track contacts that directly contact the base ***and*** emitter regions. That is, Sakamoto's metal track contacts do not contact regions of a first conductivity type (e.g., n) and regions of a second conductivity type (e.g., p). **Indeed, the metal contacts (26, 27) only contacts regions of one type of conductivity (n+).** In particular, the metal contacts (27) are in contact with the emitter region (23) having n+ conductivity, and the metal contact (26) is in contact with the "base electrode connecting portion" (24) having the **same** n+ conductivity. *See* Sakamota at FIG. 1(a); Abstract.

Furthermore, Sakamoto demonstrates that none of the metal contacts (26, 27) contact the base region (22) of second conductivity type (p). Indeed, the upper surface of the base region is completely covered by an insulating layer (29), thus preventing any contact of the base region with any metal contacts. *See id.* at para. [0039] and FIG. 1(a). Yet further, Sakamoto clearly notes that that metal contacts (26) are not formed on regions having conductivity of the base region (i.e., conductivity different from the emitter region). *See id.* at paras. [0040]-[0041]; *see also* para. [0040] ("[F]ormed in the base region 22 is a different conductivity type base electrode connection portion 24 from that of the base region, and connected to the different conductivity type [relative to that of the base region, and similar to that of the emitter regions (23)] base electrode connection portion 24 is the base electrode [or "metal contact"] 26."

This structure in Sakamoto is absolutely fundamental to the operation of the device disclosed in Sakamoto because the additional junction present in Sakamoto creates the Zener diode functionality of the device. *See* Sakamoto at paras. [0021] and [0022]. As such, Sakamoto does not disclose a bipolar transistor in which the metal layer provides metal track contacts that **directly contact** the base **and** emitter regions.

Furthermore, in contrast to claim 1, Sakamoto does not disclose that a thickness of the metal layer is substantially uniform (and greater than 3μm). Indeed, as shown in FIG. 1(a) of Sakamoto, for the "T"-shaped metal contacts (26, 27), the thickness over each of the base

electrode connecting portion (23) and emitter regions (24) is shown as twice that over the insulation film (29). As such, Sakamoto does not disclose a bipolar transistor with a metal layer having a substantially uniform thickness.

Accordingly, Sakamoto, alone or modified as suggested by the Examiner, does not disclose a bipolar transistor in which (i) a metal layer provides metal track contacts that **directly contact** the base **and** emitter regions; and (ii) a thickness of the metal layer that is **substantially uniform** (and greater than 3μm).

To establish a prima facie obviousness of a claim invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981 (CCPA 1974). Because Sakamoto does not teach or suggest the recited features of claim 1, there can be no prima facie obviousness by seeking to combine these references.

B. It would not have been obvious to increase metal layer thickness.

As acknowledged by the Examiner, Sakamoto does not disclose "the thickness of said metal layer is greater than 3 microns." *See Office Action* at section 5. As a result, the Examiner argues that it would have been obvious to one of ordinary skill to determine the optimum thickness. *See id.* In addition, with respect to claim 10, the Examiner cites Gardes, which according to the Examiner discloses "how an increasing thickness of a metal layer will result in decreases in series resistance as well as a small voltage drop (see Fig. 1, para. 33)." *See id.*

Further to the Responses (dated October 19, 2009 and May 20, 2010, both of which are herein incorporated by reference in their entirety) to the previous Office Actions, the process of increasing metal layer thickness produces considerable process disadvantages for the skilled person attempting to fabricate the devices claimed.

Applicant submits with this response, as evidence of the difficulties inherent in increasing the thickness of metal contact layers, a copy of U.S. patent 7,517,810. In the background section of this publication, in column 1, it is explained that there are many difficulties and disadvantages with the use of thick metal films. Wet etching, as is normally used for the etching of metal contact films, leads to isotropic etching and causes substantial undercutting for etched metal

contacts. This leads to considerable wastage of silicon area under the contact. **This wastage of silicon area is in direct contradiction to the required reduction in overall saturation resistance** for a saturated switch transistor device.

As explained in the Responses, the reduction in resistance expected by the skilled person from an increase in metal thickness from, for example, 3 microns to 4 microns would be negligible as the skilled person would not have been aware that an increase in thickness of the metal layer can lead to a surprising and unexpected drop in series resistance which arises from greater uniformity of the biasing voltage applied across the base, thus ensuring that all of the transistor's effective operating area is fully switched into an "on" state.

Given the expectation by the skilled person of only a minor reduction in saturation resistance by increasing metal layer thickness, and with the skilled person being aware of the problems in processing difficulty (e.g., considerably longer deposition and etch times) and of the loss of silicon effective surface area that would arise from thickening the metal layer, there would be no incentive for the skilled person to attempt an experimental program to monitor the effect of metal contact thickness on resistance.

Also as previously noted, it is not possible to carry out such experiments under laboratory conditions on a small scale. In order to reliably look into the effects, the devices would have to be made on a full-scale production facility at enormous cost, inconvenience, and production loss. It is only with the inventive insight that a much larger drop in resistance is achievable than might be expected (because this arises from increased uniformity of biasing rather than any simple resistive effect of the contact layer) that the prejudice against an unnecessary and costly increase in metal layer thickness would be tested.

The Examiner seems to be confusing the expected effect of a tiny drop in series resistance that would arise from the metal contacts alone with the ***completely unexpected drop*** that is found in practice. The Examiner's assertion that the skilled person would experiment to optimize the contact thickness is correct. The contact metal thickness had already been optimized at the time of the invention, and as a result, the use of uniform metal contact thicknesses in excess of 3 microns was considered impractical and ineffective, because of process difficulties such as those

set out in U.S. 7,517,810. The loss in effective silicon area that would result from thick metal layers already meant that layers thicker than about 3 microns were not considered as a realistic option.

As previously noted, the skilled person in this field would have been well aware that etching of metal contacts to provide the matrix of metal track connections would become considerably more difficult and unreliable as the thickness of the metal layer was increased. It was accepted in the field at that time that an increase in metal contact layer thickness would only be expected to provide a "series" reduction in the resistance of the "on" transistor. Given that the series contribution of the contact resistance to the overall resistance was minimal (e.g., 5% of the total resistance), even a 50% improvement from doubling the thickness would only be expected to give a 2.5% improvement in the overall resistance of the device.

Hence, in the field at the time of the invention, no one skilled in the art believed (nor was there any teaching) that increasing the metal track thickness would provide any additional benefit that would outweigh the additional process times and loss in reliability (arising from greater undercut during etching) that would result from any increase in metal thickness. Thus, as noted, the industry had settled on a "normal" metal track thickness of about 2 microns as providing a reasonable balance between short process time and insignificant contribution to series resistance in a device. It must be emphasized that due to the physical constraints of putting the matrix of metal track contacts in place by etching, an increase in thickness is highly undesirable.

The Applicant refused to believe that no further improvement beyond the generally accepted best specific area resistance of 100 - 200 mOhm.mm2 was possible, and went against the accepted prejudice that no significant improvement could arise from increasing the metal contact thickness. Surprisingly, the drop in $V_{CE(sat)}$ that could be achieved was considerably greater than would have been expected form the series resistance contribution of the metal tracks. This can now be explained as arising from improvement in the uniformity of "on" biasing along the length of the track, but this effect was completely **unexpected** and had not been predicted or taught prior to the invention. It was only by challenging the existing prejudices, carrying out difficult and expensive trials, and overcoming the technical difficulties and process negatives

(e.g., longer deposition times, undercutting) associated with the use of thicker metal layers that the discovery of the unexpected benefit was made.

It should be emphasized once again that **testing the effect of increasing metal layer thickness was not the sort of experiment that could be carried out as a pilot experiment on a bench scale**. The effect would not have been found other than in a "full scale" matrix device with an already optimized low $V_{CE(sat)}$. Modifying a production facility to **increase** production times and **reduce** production reliability in order to seek an unexpected and unpredicted benefit is not "obvious" behavior. The teaching in Gardes that an increase in thickness would lead to a small reduction in series resistance would never have convinced the skilled person to increase thickness on a production facility with any expectation of a benefit that outweighed the difficulties associated with even a small increase in metal thickness.

Therefore, for at least the reasons above, Sakamoto does not anticipate, suggest, or render predictable independent claims 1.

Independent claim 10 is allowable for at least the same reasons as independent claim 1 and for reasons apparent from the claim language.

In addition, because claims 2, 3, 5, 7, 8, and 11-14 depend from claim 1 (directly or indirectly), each of the claims is allowable for at least the same reasons as claims 1 and for additional reasons apparent from the claim language.

Accordingly, the rejections of claims 1, 2, 3, 5, 7, 8, and 10-14, as amended herein, is respectfully traversed.

III. New Claims

New claims 15-19 are added to further protect additional features of the present invention. Each of these claims is not disclosed or suggested by the cited references. Moreover, each of these claims is allowable at least for the reasons of its parent claim and/or the reasons previously discussed.

A. Claim 15

Claim 15 generally recites, among other features,

> wherein at least some of the metal track contacts directly contact the base region.

This claim is supported by the original application, for example, in Figure 1 and page 4 of the pending application.

B. Claim 16

Claim 16 generally recites, among other features,

> wherein the metal track contacts comprise base metal contacts and emitter metal contacts, the base metal contacts for contacting the base region, the emitter metal contacts for contacting the emitter region.

This claim is supported by the original application, for example, in Figure 1 and page 4 of the pending application.

C. Claim 17

Claim 17 generally recites, among other features,

> wherein a thickness of the base metal contacts is substantially uniformly greater than 3μm.

This claim is supported by the original application, for example, in page 5 of the pending application.

D. Claim 18

Claim 18 generally recites, among other features,

> wherein a thickness of the emitter metal contacts is substantially uniformly greater than 3μm.

This claim is supported by the original application, for example, in page 5 of the pending application.

E. Claim 19

Claim 19 generally recites, among other features,

wherein the first conductivity type is a conductivity opposite a conductivity of the second conductivity type.

This claim is supported by the original application, for example, in Figure 1 and page 5.

IV. Conclusion

Applicant believes that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.

The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by the credit card payment instructions in EFS-Web being incorrect or absent, resulting in a rejected or incorrect credit card transaction, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

Respectfully submitted,

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